

New England University Transportation Center



NE University Transportation Center
77 Massachusetts Avenue, E40-279
Cambridge, MA 02139
Phone: 617-253-0753
Fax: 617-258-7570
web.mit.edu/utc

Principal Investigator: Bryan Reimer
Title: Research Scientist
University: MIT
Email: reimer@mit.edu
Phone: (617) 452-2177

Co-Principal Investigator:
Title:
University:
Email:
Phone:

Final Report

Project Title:

Age related changes in cognitive response style in the driving task
Part II

Project Number:

MITR20-5

Project End Date:

4/30/13

Submission Date:

05/10/13

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or the use thereof.

The New England University Transportation Center is a consortium of 8 universities funded by the U.S. Department of Transportation, University Transportation Centers Program. Members of the consortium are MIT, the University of Connecticut, University of Maine, University of Massachusetts,

This project further explored the patterns in drivers' physiological arousal to periods of heightened cognitive workload. Various physiological measures have been well established to increase with escalating cognitive workload (Backs & Seljos, 1994; Veltman & Gaillard, 1998). While in many cases heart rate increases with cognitive demand, results from a set of driving simulation studies completed as part of this project illustrate that situations exist where an increase in overt cognitive demand does not result in an increase in heart rate. In essence, this research suggests that there are cognitively demanding situations where heart rate may increase or decrease, depending on how attention is directed or allocated. B. C. Lacey and Lacey (1974) and J. I. Lacey, Kagan, Lacey, and Moss (1963) suggest that heart rate deceleration is associated with an attentional state involving the intake of environmental stimuli (a broad ranging external focus), while heart rate acceleration may be related to an attentional style that involves selectively ignoring or rejecting input that may be disruptive or distracting to a focused cognitive task.

In the first phase of this project, other than having consistently higher heart rates, what appeared to differentiate late middle age and younger drivers was not so much a specific pattern of response to a cell phone task, but the relative distribution of individuals showing increases, decreases, or unchanged heart rates (Reimer, Mehler, Coughlin, Roy & Dusek, 2011). As part of this project, a subsequent assessment (Mehler, Reimer, Pohlmeier, & Coughlin, 2008) considered data on a continuous performance task and found consistent results. In both of these cases, it was speculated that differences in attentional style was the underlying phenomena driving these observations. However, skin conductance, a complementary measure of arousal that could further strengthen this speculation, was not recorded.

As part of an investigation of task pacing and driver workload, recent research (Mehler & Reimer, 2013) investigated physiological responses to a task that required participants to listen to a series of digests. Heart rate during the task was observed to be at a lower level than seen during a period just prior to a manipulation of cognitive demands (baseline driving) and indistinguishable from the heart rate recorded during a "just drive" condition. Skin conductance, on the other hand, appeared higher during the listening task than in either of the single task driving periods. Thus, the data provide a clear illustration of the divergent patterns of heart rate and skin conductance typically associated with the "sensory intake" state (Lacey & Lacey, 1974) that was speculated as the root cause of the differences in the patterning of heart rate between younger and middle age drivers observed in the earlier work. Perhaps equally intriguing, in Mehler et al. (2008) in younger drivers, heart rate was not associated with driving or secondary task performance. However, in the late middle age drivers, cases illustrating an increase in heart rate with added demand showed higher performance on the secondary task, drove faster, and exhibited more stable velocity control. Late middle age drivers who did not exhibit heart rate acceleration to the secondary demand slowed significantly during the dual task period. While speculative, this data illustrates the need for additional research in the use of multiple physiological measures of driver arousal to categorize increased arousal during the driving task and to better understand the impact of different sensory states on driving performance. Three publications resulting from this project detail the technical results:

Mehler, B., Reimer, B., Pohlmeier, A.E. & Coughlin, J.F. (2008). The association between heart rate reactivity and driving performance under dual task demand in late middle age drivers. *Advances in Transportation Studies an International Journal. Special Issue*, 53-70.

Abstract: Physiological indices of arousal generally increase when heightened demands are placed on an individual's cognitive resources. As a consequence, measures such as heart rate are frequently used as one method of assessing changes in workload. In a simulation study with young adult (19-23 yrs.) and late middle age (51-66 yrs.) drivers, heart rate responses were compared during a variety of dual task conditions along with driving and task performance data. During two of the tasks in which younger participants showed significant heart rate acceleration, older drivers, as a group, showed little or no change in heart rate. In this paper we present data on a more detailed analysis of the relationship between heart rate change and performance during one of the dual load conditions, a continuous performance task (CPT). The sample was subdivided into individuals who showed a substantive heart rate acceleration

response during the task vs. those who showed little change or heart rate deceleration. Of the 18 younger and 15 older adults in the analysis, 56% of the younger and 27% of the older individuals fell into the heart rate acceleration category. Heart rate response did not correlate with performance on the CPT in the younger subjects. In the older subjects, however, the heart rate acceleration group scored significantly higher on the CPT than those who did not exhibit a pattern of heart rate acceleration. In addition to lower performance on the CPT task, older adults in the non-acceleration group showed a significant drop in driving speed, which is generally interpreted as a compensatory response employed to manage total workload. Overall, the late middle aged drivers who showed a heart rate accelerative response during the CPT task performed better on both the primary and secondary tasks than those that did not. The increase in heart rate in the late middle age drivers in this instance could serve as marker for a variety of important performance mediating variables including relative engagement in the task, availability of resources to invest in the dual tasks, attentional style, or overall flexibility of response. The results suggest the potential value of looking at differences in individual patterns of response in driving behavior studies in addition to overall group behavior. The presence of subtypes of heart rate responders, and the observed performance differences between subtypes in this paradigm, illustrate the importance of these considerations. Other heart rate patterning data from the literature is considered and suggestions for future investigation offered.

Reimer, B., Mehler, B., Coughlin, J.F., Roy, N. & Dusek, J.A. (2011). The Impact of a Naturalistic Hands-free Cellular Phone Task on Heart Rate and Simulated Driving Performance in Two Age Groups. *Transportation Research Part F: Traffic Psychology and Behaviour*, 14(1), 13-25.

Abstract: Heart rate and driving performance were assessed while late middle age (51–66) and younger adults (19–23) engaged in a naturalistic hands free phone task that was designed to place objectively equivalent cognitive demands on all participants. Although heart rate measures have been used in evaluating driver workload, prior studies had not compared responses in late middle age and younger adults with samples of sufficient size to begin to explore possible age relationships. In an evaluation of 37 participants, the two age groups displayed equivalent performance on the cellular telephone task and concurrent decrements in speed control (SD velocity). It was observed that the late middle age subjects drove more slowly overall and, as a group, did not demonstrate heart rate acceleration in response to the phone conversation that was seen in younger drivers. The possibility that age group differences in heart rate response are related to individual differences in attentional focus is raised. While there are significant reasons to discourage all individuals from engaging in phone conversations and other distracting tasks while driving, late middle age adults appeared as capable as young adults of managing the additional workload of a low to moderately demanding cognitive task of the type assessed. The tendency of individuals to adopt self-regulatory behaviors, such as a lower overall driving speed, as a function of age/experience may account for the equivalence in overt performance.

Mehler, B. & Reimer, B. (2013). An Initial Assessment of the Significance of Task Pacing on Self-Report and Physiological Measures of Workload while Driving. Paper to appear in the proceedings of the 7th International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design, Bolton Landing, New York, June 18-19, 2013.

Abstract: In block A of a simulator study, a sample of 38 drivers showed a stepwise increase in heart rate and skin conductance level (SCL) from single task driving and across 3 levels of an auditory presentation – verbal response dual task (n-back), replicating findings from on-road research. Subjective ratings showed a similar stepwise increase, establishing concurrent validity of the physiological indices as measures of workload. In block B, varying the inter-stimulus interval in the intermediate 1-back level of the task resulted in a pattern across self-report workload ratings, heart rate, and SCL suggesting that task pacing may influence effective workload. Further consideration of the impact of task pacing in auditory-verbal in-vehicle applications is indicated.